

# Alagnak Watershed Rainbow Trout Seasonal Movement

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## ABSTRACT

Adult rainbow trout were radio-tagged in two locations in the Alagnak River drainage in 1997 and 1998 and radio-tracked until March 1999. The telemetry data indicate the two different sample groups exhibited independent movements with little geographic overlap. However, some tagged fish from each sample group migrated downstream to the same general area during the spawning season. Rainbow trout within each sample group may have evolved the observed seasonal movement patterns to optimize food availability during the summer and thermal refugia in the winter.

## INTRODUCTION

Concerns have been raised about the health of the prized rainbow trout (*Oncorhynchus mykiss*) populations in the Alagnak River and its tributaries upstream in Katmai National Park. Fishing pressure has increased dramatically over the last decade, while the average size and age of rainbow trout have decreased (Jaenicke 1998). The degree to which sport fishing has influenced Alagnak populations is presently unknown. The relative lack of information regarding Alagnak rainbow trout caused the Alaska Department of Fish and Game (ADFG) to invoke emergency regulations preventing the retention of any Alagnak rainbow trout in 1996 and 1997. The Alaska Board of Fisheries in 1998 established regulations limiting Alagnak rainbow trout sport fishing to catch and release only.

Basic questions regarding the population structure need to be addressed before routine assessments of the population status can be initiated. For example, it is presently unknown whether rainbow trout in the various rivers, lakes, and tributaries of the watershed are a single, well mixed population with interbreeding spawning groups, or whether there are discrete, independent spawning populations. While it is generally believed that seasonal migrations occur, little is known about the detailed movement patterns or population intermixing. Because knowledge of basic life history characteristics is limited, it is difficult to assess the relative impacts of the increasingly popular sport fisheries. Therefore, the goal of this study was to improve our basic understanding of the population dynamics of Alagnak watershed rainbow trout. The objectives were to determine temporal and spatial aggregations, movements, and to examine evidence for population structure of rainbow trout in the Alagnak watershed through radio-telemetry.

## Study Area

The Alagnak National Wild River originates at the outlet of Kukaklek Lake and flows 120 km into the Kvichak River which drains into Bristol Bay (Figure 1). A major tributary is the Nonvianuk River which originates at Nonvianuk Lake south of Kukaklek Lake. Numerous tributaries feed into Kukaklek and Nonvianuk Lakes, the largest of which are Kulik River, Battle Creek, and Moraine Creek. The Alagnak River is extensively braided downstream of the confluence with Nonvianuk River and eventually becomes tidally influenced near its union with the Kvichak River. All but the downstream-most 29 km of the Alagnak River are managed by

Katmai National Park. The majority of the upper watershed is within the Katmai National Preserve or Katmai National Park.

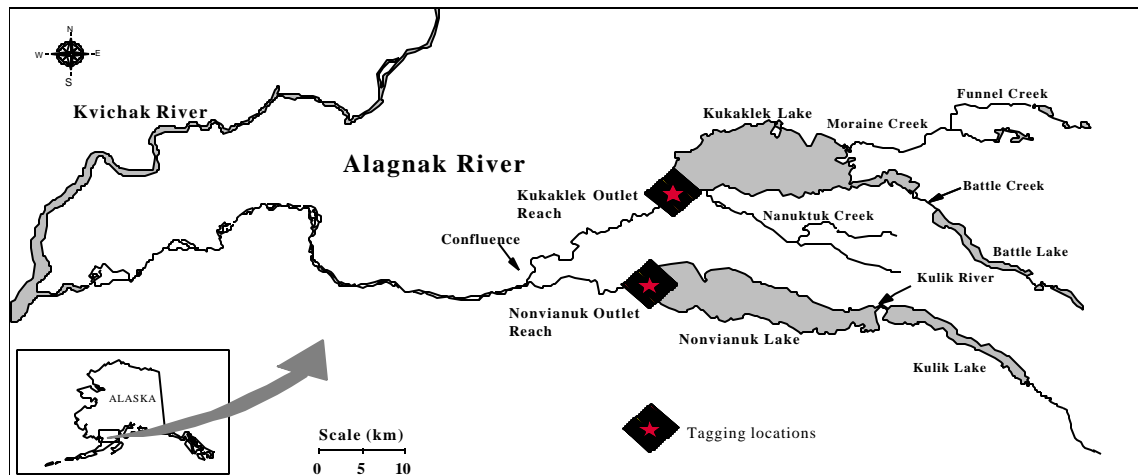


FIGURE 1. The Alagnak River watershed showing the Kukaklek and Nonvianuk Outlet tagging locations.

## METHODS

### Sampling Locations and Strategy

Fish were collected by hook and line and seine at Kukaklek and Nonvianuk Lake outlets (Figure 1). All fish were carefully handled to minimize injury. Fish captured by hook and line were landed as quickly as possible using 8-weight fly rods or spinning gear. Captured fish over 440 mm and in good health were radio-tagged during July and October 1997 and April 15-May 7, 1998. Fish to be radio-tagged were collected after the spawning period in 1997, and in 1998 fish were collected in April and early May with the intent of targeting pre-spawning aggregations so that dispersal from possible spawning subpopulations could be monitored.

### Implanting Radio Transmitters

Transmitters were tested for functionality prior to each surgery. Fish were anesthetized with an MS222 (tricane methanesulfonate) 100mg/L solution; during surgery the MS222 solution was poured continuously over the gills. The application of transmitters in both 1997 and 1998 followed standard, surgical implant protocols described by Summerfelt and Smith (1990). Each surgery averaged 5-6 minutes. Following surgery, fish were returned to a tub filled with fresh water until they were swimming upright. Before being released, fish were placed in a holding tank within the river until they reached equilibrium (approximately 30 minutes).

Transmitters (Advanced Telemetry Systems) were 56 mm long, contained a 3.5-V battery, and were encased in an electric resin epoxy. Each tag weighed 10.4-11.4 g in air which did not exceed 2% of fish weight (Winter 1983), and had a 26-cm flexible external antenna attached to one end. Standard beeper tags (model 1035) were used in 1997 having frequencies ranging between 40 and 41 MHz. A 2-MHz receiver (model R2100) was used for relocating transmitters. Pulse-coded tags (model 1035) were used in 1998 with ten individually encoded tags within each of ten frequencies ranging between 40 and 41 MHz (100 tag potential). Tags released in 1998 were identified using the data logger DC II model D5041/receiver set which records date, time, frequency, and identification of each tag. Information stored in the receiver/data logger was downloaded and processed once the summer field season was over and following every aerial flight during winter.

### **Radio-tag Relocations**

Fish were relocated using a combination of aerial, boat, and foot tracking surveys. Aerial telemetry surveys of the Alagnak main stem, Kukaklek and Nonvianuk Lakes, and the tributaries were conducted once a month, weather permitting, from July 1997 to March 1999 using fixed-wing aircraft equipped with two tuned-loop antennae, one attached to each wing strut. Flights along the main stem Alagnak averaged 300 m above ground in 1997 and 180 m above ground in 1998; flights over the lakes averaged 300 m in both years. Boat and foot telemetry surveys were conducted every 2-3 days on the main stem Alagnak only, during July-October 1997 and during April-September 1998. Final determinations of tag location depended on the observer deciding where the peak signal occurred. Therefore, boat and foot relocations were considered to be more accurate than aerial relocations. All locations where a tagged fish was identified were recorded either by a written description or using a portable Global Positioning System (GPS) unit. All relocations were converted to latitude and longitude, with the accuracy depending on the method of relocation.

### **Telemetry Data Management and GIS Analysis**

Information from 1997-1999 telemetry surveys was combined into one database. If a given radio tag did not move after three consecutive aerial and/or boat relocations, we attempted to recover the radio tag and thereby determine whether the fish was dead or the tag had been expelled. Tags that were not relocated for six consecutive months were considered to have failed and were recorded as missing. A radio tag was no longer tracked only after the transmitter was recovered during a ground survey.

Geographical analysis of fish movement was done using ArcInfo software. A GIS-based map of the Alagnak drainage was digitized and river kilometers were calculated. This mapping system was then used as a base reference to determine the distance and direction of movements.

***Interbasin mixing and local site fidelity.*** To test for interbasin mixing, we compared the distributions of radio-tagged fish released at the Nonvianuk and Kukaklek Lake outlets to determine whether they moved between drainages. To reveal any patterns of local site fidelity, the distance each radio-tagged fish ventured from its release site was calculated for each month (Figure 2).

***Seasonal movement.*** To determine seasonal movement patterns, movement of radio-tagged fish was characterized by graphically comparing the river reach in which they were tagged to the river reaches in which they were subsequently relocated. We also calculated the mean distances moved during summer (April-September) and winter (October-March) for tagged fish with at least 4 relocations to determine if seasonal differences in movement existed (Table 1).

## **RESULTS**

### **Radio-telemetry**

***Fish tagged at Kukaklek Lake Outlet.*** Ten radio transmitters were implanted into rainbow trout at the Kukaklek outlet in July 1997. Two fish were relocated only once following surgery, and two were considered to be dead or to have expelled their tags within six months of release. Of the remaining six fish, three were considered to be missing or have tag failure and one died or expelled the tag in 1998. Twenty-one fish were implanted with radio transmitters at Kukaklek Outlet in April and May 1998. An estimated seven tags (33%) experienced battery failure within the first five months following release. Four fish were considered mortalities or to have expelled

their tags during the summer of 1998. A total of sixteen fish tagged at Kukaklek (from both tagging years) were successfully relocated for 5-9 months (not necessarily consecutive).

***Fish tagged at Nonvianuk Lake Outlet.*** Ten fish were implanted with radio transmitters in July 1997 at Nonvianuk Lake Outlet. Three fish were considered dead or to have expelled their tags and four fish either disappeared or experienced tag failure during 1998. Nineteen fish were radio-tagged at Nonvianuk Outlet in April 1998. Ten fish either died or expelled their tags within four months following surgery, and an estimated seven fish (37%) experienced tag failure. A total of eleven fish tagged at Nonvianuk (from both tagging years) were successfully relocated for 6-14 months (not necessarily consecutive).

Tracking of fish tagged at both outlets in 1997 ceased in January 1999 due to expected battery expiration. All radio tracking ceased as of April 1999 due to the few remaining functional 1998 transmitters (Kukaklek n=11, Nonvianuk n=2).

***Interbasin mixing and local site fidelity.*** There were no recorded movements between drainages by either tagging group. During the suspected spawning season (May-June) 11 out of the 21 fish tagged at Kukaklek in 1998 moved downstream to the upper and middle sections of the Alagnak main stem. Eleven fish tagged at the Nonvianuk Outlet (both tagging years) were also using the same main stem river sections during the spawning period. However, fish from each of these groups either returned to their respective lake basins, remained in the upper or middle main stem, or the radio tags were never relocated.

The examination of Figure 2 indicates a wide variation in movement (km) from tagging location by month. There was no strong indication of site fidelity at either lake outlet tagging site, except for several fish released at Nonvianuk Outlet in 1997 which remained in the area for 7-13 months. Most other fish spent the majority of their time in the lakes. Further analysis will be required to determine whether they exhibited site fidelity.

***Seasonal movement.*** Movement of both tagging groups varied more during summer months than winter months (Table 1, Figure 2). The mean movement for Kukaklek and Nonvianuk fish from both tagging years in the summer was 38 km; the mean movement for both groups in winter was 6.9 km (Table 1). There appeared to be a general movement of tagged fish downstream, perhaps to spawn in May-June, with a general subsequent return upstream (Figure 2).

TABLE 1. Mean movement (km) for Kukaklek and Nonvianuk tagged rainbow trout during designated winter (October-March 1997, 1998) and summer (April-September 1997, 1998) months. Sample sizes consist of fish that had at least 4 relocations during the winter or summer periods.

	Mean	SD	Min	Max (km)
Winter : Kukaklek (n=4); Nonvianuk (n=7)	6.9	8.0	0	25.0
Summer: Kukaklek (n=10); Nonvianuk (n=13)	38.0	29.4	0	97.0

Kukaklek fish tagged in 1997 were not relocated anywhere within the drainage during May and June 1998. During the suspected spawning period of May-June 1998, 11 of the 21 fish tagged at Kukaklek in 1998 had moved downstream to the upper or middle sections of the Alagnak main stem. Five of the 11 returned to the tagging area during summer, four tags were recovered in the main stem, and two tags were never relocated (suspected tag failure).

Four of the 10 Nonvianuk fish tagged in 1997 were located in the upper or middle Alagnak sections during the May-June 1998 spawning period. Two returned to the tagging area later in the summer, one tag was recovered in the main stem, and one fish repeated the same downstream movement during both summers and returned to the Nonvianuk tagging area in the fall of both years. Ten of the 19 fish tagged at the Nonvianuk Outlet in 1998 moved down to the upper or middle main stem Alagnak during May-June 1998. Three of those returned to the Nonvianuk tagging area later in the summer, five tags were recovered in the main stem, and two were never relocated (suspected tag failure).

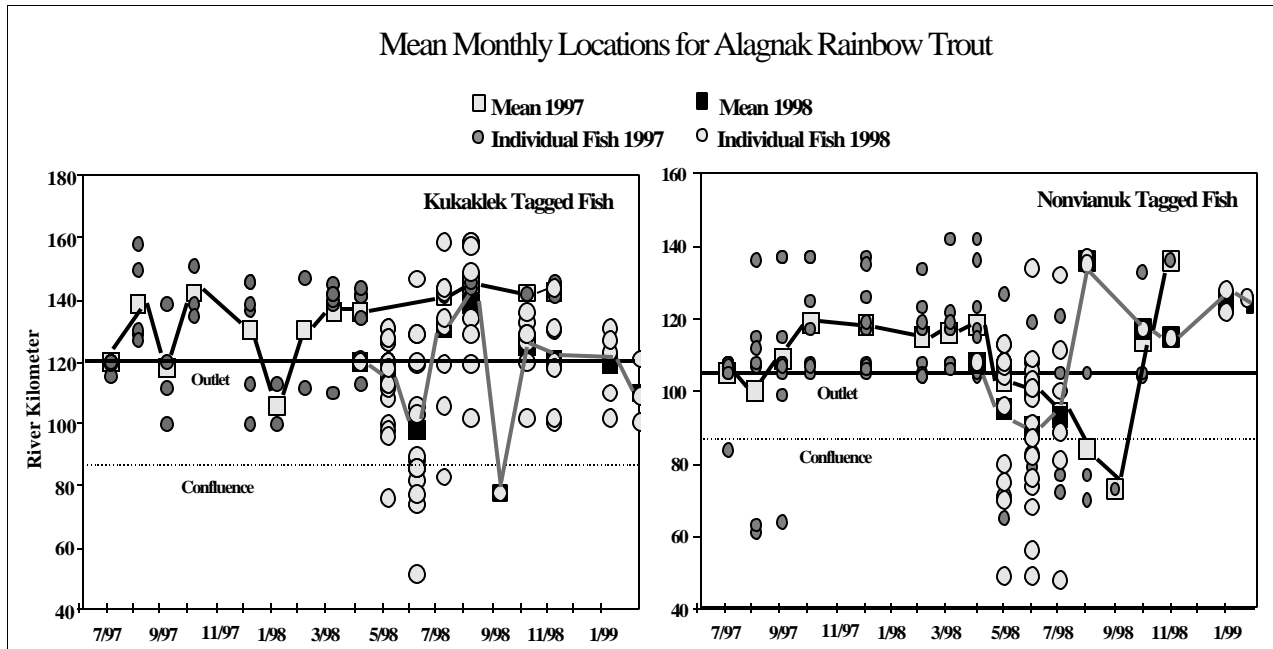


FIGURE 2. Mean monthly locations of Kukaklek and Nonvianuk Outlet tagged fish. The circles represent one fish's mean location for that month. The squares represent the mean for all fish locations for that month. The line labeled "Outlet" depicts the lake outlet tagging location relative to the mouth of the Alagnak River (e.g., Kukaklek Outlet is located 120 km above the mouth). The dotted line labeled "Confluence" represents the confluence of the Alagnak and Nonvianuk rivers; below the Confluence line represents the Alagnak main stem.

## DISCUSSION

There was no migration or movement of rainbow trout tagged at Kukaklek and Nonvianuk Lake outlets from one lake, outlet reach, and tributary watershed to the other, indicating watershed fidelity and potential reproductive isolation. However, some fish from each lake watershed do seem to mingle in the upper and middle Alagnak main stem during the apparent spawning period of May-June. The final conclusion of whether these two major tributaries hold distinct rainbow trout populations will depend on the outcome of molecular genetic analysis.

The examination of individual movement (Figure 2) indicates that some fish stay in a very restricted location for extended periods, but the majority do not. Movements apparently are much more confined in winter than summer (Figure 2, Table 1). Fish tend to stay in the lakes or lake outlet reaches in winter, perhaps because these areas are typically warmer in winter compared to

tributaries (Hutchinson 1975) therefore providing thermal refugia from extreme cold and ice formation. Most of the tagged fish appeared to be residents of the lakes or lake outlets, although there is significant seasonal movement of some fish downstream to the main stem Alagnak during spawning season. Following spawning time, there is noticeable movement throughout summer, both upstream and downstream, perhaps because rainbow trout follow spawning salmon to utilize their eggs and flesh as a food resource (Brink 1995, Eastman 1996).

We encountered many difficulties and challenges with our telemetry equipment and radio tags during 1998. Approximately 35% of our 1998 radio tags failed due to battery malfunction and programming problems. In addition to battery failure, the data loggers performed inconsistently. The combination of malfunctions resulted in our decision to cease radio tracking after only one year (tags were scheduled to function for two years).

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